LVDS Advantages

Chapter 2

2.0.0 LVDS ADVANTAGES

2.1.0 LVDS ELECTRICAL CHARACTERISTICS

LVDS current-mode, low-swing outputs mean that LVDS can drive at high-speeds (up to several hundred or even thousands of Mbps over short distances). If high-speed differential design techniques are used, signal noise and electromagnetic interference (EMI) can also be reduced with LVDS because of:

1. The low output voltage swing (≈350mV)

2. Relatively slow edge rates, dV/dt ≈ 0.300V/0.3ns = 1V/ns

3. Differential (odd mode operation) so magnetic fields tend to cancel

4. "Soft" output corner transitions

5. Minimum I_{CC} spikes due to low current-mode operation

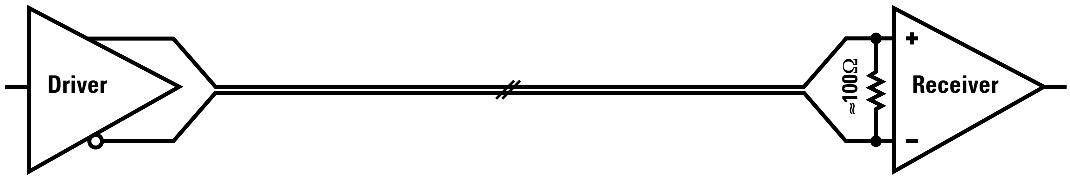
LVDS can be designed using CMOS processes, allowing LVDS to be integrated with standard digital blocks. LVDS can be used in commercial, industrial, and even military temperature ranges and operate from power supplies down to 2 volts. LVDS uses common copper PCB traces and readily available cables and connectors as transmission media, unlike fiber optics.

Presently the major limitations of LVDS are its point-to-point nature (as opposed to multipoint – see Bus LVDS) and short transmission distance (10-15m), where other technologies must presently be used.

Advantages	LVDS	PECL	Optics	RS-422	GTL	TTL
Data rate up to 1Gbps	+	+	+	-	-	-
Very low skew	+	+	+	-	+	-
Low dynamic power	+	-	+	-	-	-
Cost effective	+	-	-	+	+	+
Low noise/EMI	+	+	+	-	-	-
Single power supply/reference	+	-	+	+	-	+
Migration path to low voltage	+	-	+	-	+	+
Simple termination	+	-	-	+	-	+
Wide common-mode range	-	+	+	+	-	-
Process independent	+	-	+	+	+	+
Allows integration w/digital	+	-	-	-	+	+
Cable breakage/splicing issues	+	+	-	+	+	+
Long distance transmission	-	+	+	+	-	-
Industrial temp/voltage range	+	+	+	+	+	+

2.2.0 LVDS DRIVERS & RECEIVERS

The most basic LVDS devices are the driver and receiver. These translate TTL to LVDS and back to TTL.

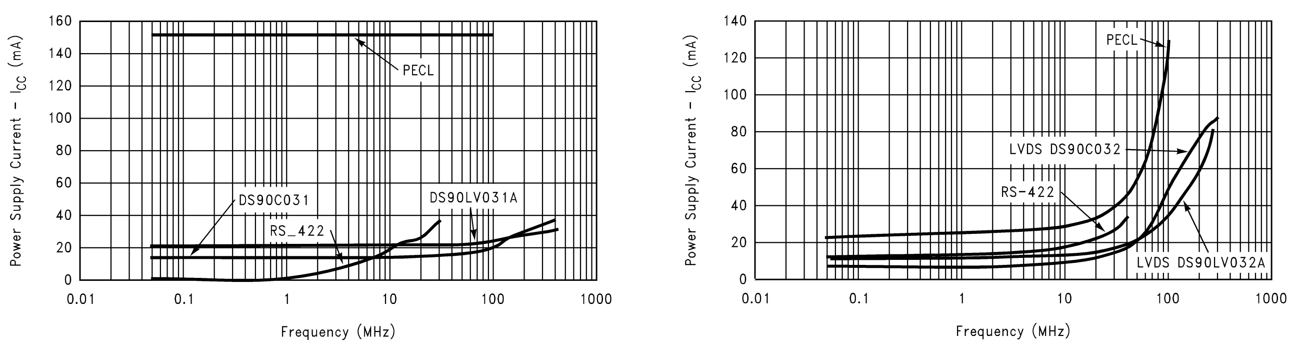


LVDS Drivers and Receivers Convert TTL to LVDS and Back to TTL.

Drivers and receivers transmit high-speed data across distances up to 10m with very low power, noise and cost.

Parameter	LVDS	PECL	Optics	RS-422	GTL	TTL
Output voltage swing	±350mV	±800mV	n/a	±2V	1.2V	2.4V
Receiver threshold	±100mV	±200mV	n/a	±200mV	100mV	1.2V
Speed (Mbps)	>400	>400	>1000	<30	<200	<100
Dynamic power	Low	High	Low	Low	High	High
Noise	Low	Low	Low	Low	Med	High
Cost	Low	High	High	Low	Low	Low

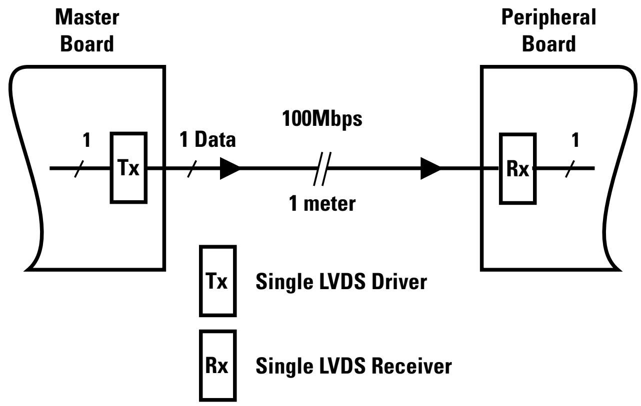
The table above summarizes that only LVDS can deliver the high-speed, ultra-low power, and low cost without compromise. PECL and ECL are expensive and consume too much power. TTL/CMOS is cheap, but is noisy and burns a lot of power at high-speeds. Fiber optics are expensive and have cables and connectors which are hard to manage.



I_{CC} vs. Frequency for 5V DS90C031/032 LVDS, 41LG/LF PECL, and 26C31/32 RS-422 Devices.

2.2.1 100Mbps Serial Interconnect

LVDS drivers and receivers are generally used to create serial or pseudo-serial point-to-point interconnects from 1Mbps to >400Mbps per channel. The following example summarizes the total performance and cost advantages of using LVDS over PECL or TTL for a serial 100Mbps 1 meter point-to-point link. Significantly higher data rates can be achieved for LVDS and PECL.



100Mbps Board-to-Board Link

100Mbps Serial Bitstream

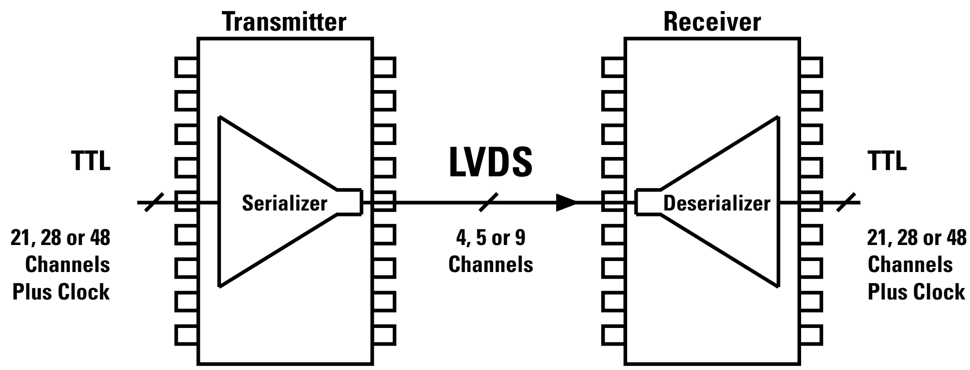
Performance Estimate				
Characteristic	**Parameter**	**LVDS**	**TTL**	**PECL**
Speed	Application Data Rate (Mbps)	100	100	100
	Max Capability per Channel (Mbps)	400	100	400
Power Consumption	Dynamic (mA) (@ 50MHz)	Low	High	Medium
	Static (mA)	8	10	48
Noise	Low EMI	+++	- - -	++
	Low Bounce	+++	- - -	++
Relative System Cost	**Total**	**4.05**	**3.30**	**6.10**
Cost Estimate				
Subsystem	**Parameter**	**LVDS**	**TTL**	**PECL**
General	Single-Ended or Differential	Differential	Single-Ended	Differential
	TTL Bus Width	1	1	1
	TTL Bus Speed (MHz)	50	50	50
	# Master Boards	1	1	1
	# Slave Boards	1	1	1
Transceivers	Description	DS90LV017A/018A	74LVT125	10ELT20/21
	# Drivers/Board (Master Board)	1	1	1
	# Rec/Board (Peripheral Board)	1	1	1
	Unit Cost	0.70	0.55	2.00
	Silicon Cost per Board	1.40	1.10	4.00
Termination	Voltage	None	None	None
	# Termination Regulators	0	0	0
	Unit Cost	0.00	0.00	0
	# Termination Resistors	1	2	2
	Unit Cost	0.05	0.05	0.05
	# Termination Capacitors	0	0	0
	Unit Cost	0.00	0.00	0.00
	Total Termination Cost	0.05	0.10	0.10
Transmission Medium	Cable Type	2 Pair CAT3	2 Pair CAT3	2 Pair CAT3
	Distance	1m	1m	1m
	#Conductors	2	2	2
	#Cables	1	1	1
	Connector Type	4-pin Wire to Board	4-pin Wire to Board	4-pin Wire to Board
	Unit Cable+Connector Assembly Cost	2.00	2.00	2.00
	Total Media Cost	2.00	2.00	2.00
Total Relative System Cost		**3.45**	**3.20**	**6.10**

Performance and Cost Estimates

The preceding example shows that LVDS provides a high-speed link with minimal noise, power, and cost. LVDS also creates an easy migration path to higher speeds, lower supply voltages, and higher integration that the other do not.

2.3.0 LVDS CHANNEL LINK SERIALIZERS

The speed of the LVDS line drivers and receivers is limited by how fast the TTL signals can be switched. Therefore, National has introduced a family of Channel Link serializers and deserializers. Instead of using one LVDS channel for every TTL channel, the Channel Link devices send multiple TTL channels through every LVDS channel thereby matching the speed of LVDS to that of TTL.



National's Channel Link Serializers/Deserializers can Dramatically Reduce the Size (and Cost) of Cables and Connectors.

Using fewer channels to convey data also means power and noise can be lower. The biggest advantage, however, is the significant reduction of cable and connector size. Since cables and connectors are usually quite expensive compared to silicon, dramatic cost savings can be achieved. Channel Link chipsets reduce cable size by up to 80%, reducing cable costs by as much as 50%. Plus, smaller cables are more flexible and user-friendly.

LVDS Channel Link serializer/deserializer devices take the inherent high-speed low power, noise, and cost advantages of LVDS and capitalize on the slow speed of TTL to generate significant benefits. For a small increase in silicon cost, Channel Link products can dramatically reduce total system costs and improve total system performance. Therefore, the total system should be evaluated if the true advantages are to be quantified. The following sections summarizes the cost and performance benefits of using Channel Link devices.

2.2.1 1Gbps 16-bit Interconnect

National's Channel Link serializers/deserializers take the benefits of LVDS (high-speed and low power, noise, and cost) and add serialization to further reduce cable, connector, and PCB size and cost. Channel Link is a great solution for high-speed data bus extension when the overhead of protocols is not desired. The following example compares the total performance and cost of moving a 16-bit 66MHz bus across 1 meter of cable using the 3V 66MHz 21-bit DS90CR215/216 Channel Link devices versus other solutions. Driving TTL signals over 1 meter of distance may be very risky due to the limited tolerance to noise (<400mV) and also transmission line problems generated by the TTL driver.

16-Bit Cable Interconnect

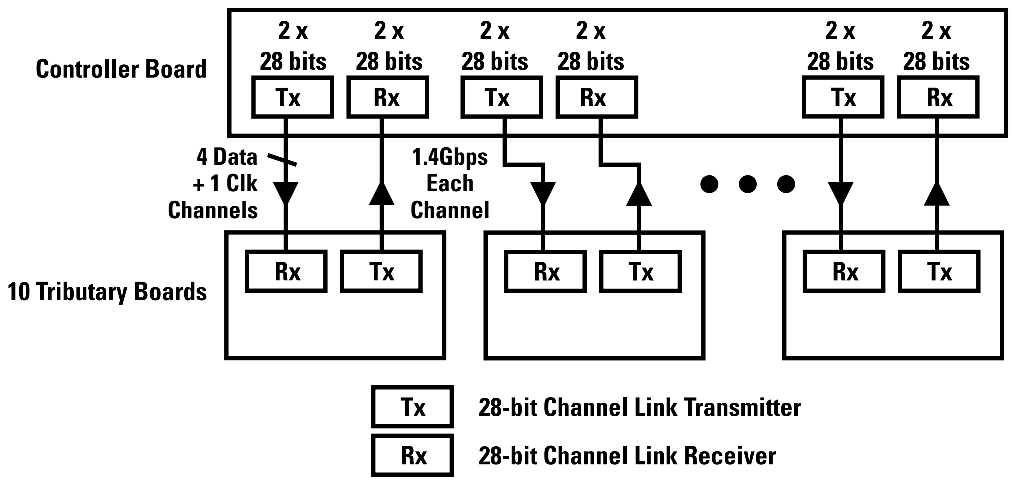
Performance Estimate						
Characteristic	**Parameter**	**Channel Link**	**TTL**	**GTL**	**ECL**	**Fibre Channel**
Speed	Application Data Rate (Mbps)	1056	1056	1056	1056	1056
	Max Capability per Channel (Mbps)	462	100	150	800	800
Power Consumption	Dynamic (mA) (@ 66MHz)	180	300	500	300	?
	Static (mA) (Outputs Disabled)	0.02 (Power Dn)	1	50	50	135
Noise	Low EMI	+++	- - -	- -	+	+++
	Low Bounce	+++	- - -	- -	++	+++
Ergonomics	Compact System Size	+++	- -	- -	- - -	+++
	Compact Transmission Medium Size	+++	-	+	+	+++
	Low Weight	+++	-	-	-	+++
Relative System Cost	**Total**	**25.50**	**55.80**	**58.80**	**71.80**	**77.60**

Cost Estimate						
Subsystem	**Parameter**	**Channel Link**	**TTL**	**GTL**	**ECL**	**Fibre Channel**
General	Single-Ended or Differential	Differential	Single-Ended	Single-Ended	Differential	Differential ECL
	TTL Bus Width	16	16	16	16	16
	TTL Bus Speed (MHz)	66	66	66	66	66
	Multiplexed Scheme?	Yes	No	No	No	Yes
	# Master Boards	1	1	1	1	1
	# Slave Boards	1	1	1	1	1
Transceivers	Description	3V 21:4 Channel Link	ALVT 16-Bit	GTL 18-Bit	9-Bit Translators	Fibre Channel
	# Drivers/Board (Master Board)	1	1	1	2	1
	# Rec/Board (Peripheral Board)	1	1	1	2	1
	Unit Cost	3.70	2.40	3.25	5.00	20.00
	Silicon Cost per Board	7.40	4.80	6.50	20.00	40.00
PC Board	Layers	4	12	12	12	12
	Size (Normalized)	1.15	1	1.15	15.63	11.97
	Total Additional PCB Cost	0.00	15.00	15.00	15.00	15.00
Termination	Voltage	None	None	1.5V	2.1V	3.0V
	# Termination Regulators	0	0	1	1	1
	Unit Cost	0.00	0.00	1.00	1.00	1.00
	# Termination Resistors	10	16	16	16	32
	Unit Cost	0.05	0.05	0.05	0.05	0.05
	# Termination Capacitors	0	0	0	0	0
	Unit Cost	0.00	0.00	0.00	0.00	0.00
	Total Termination Cost	0.50	0.80	1.80	1.80	2.60
Transmission Medium	Cable Type	SCSI2 CAT3 Cable	Shielded Flat Cable	Shielded Flat Cable	SCSI2 CAT3 Cable	CAT5 Cable
	Distance	2m	2m	2m	2m	2m
	#Data+Clock Conductors	8	17	17	34	2
	#Power+Ground Conductors	4	10	10	15	2
	#Cables	1	1	1	1	1
	Connector Type	0.050 D - 20	D - 37	D - 37	0.050 D - 50	DB-9
	Unit Cable+Connector Assembly Cost	20.00	30.00	30.00	30.00	15.00
	Total Media Cost	15.00	30.00	30.00	30.00	15.00
Power Supply	Special Supply Voltages	0	0	1.5V	2.1V	3.0V
	Power Supply Size (Normalized)	1	1.3	1.2	1.2	1.2
	Total Add'l Power Supply Cost	0.00	5.00	5.00	5.00	5.00
Total Relative System Cost		**22.90**	**55.60**	**58.30**	**71.80**	**77.60**

Performance and Cost Estimates

2.2.2 1.4Gbps 56-Bit Backplane

In some large datacom and telecom systems, it is necessary to construct a very large, high-speed backplane. There is generally an inverse relationship between the size of a backplane and its maximum speed. In other words, if you try to make a backplane too large, the heavy loading will severely hamper backplane speed and make power and noise a big problem. Therefore, connecting or extending smaller backplanes via a high-speed cable interconnect is often the only solution. The previous examples illustrates how Channel Link may be used to accomplish this over cable. The cost benefits of using Channel Link to shrink cable and connector costs are clear. What would happen, however, if Channel Link were used to form or extend a backplane using a PCB as the medium. The following examples shows how Channel Link can reduce the size and number of layers of the printed circuit board transmission medium in the same way as Channel Link reduces the size and cost of cables.



1.4Gbps Backplane Using Point-to-Point Channel Links

56-Bit Backplane

Performance Estimate						
Characteristic	**Parameter**	**Channel Link**	**TTL**	**GTL/BTL**	**ECL**	**Fibre Channel**
Speed	Application Data Rate (Mbps)	1400	1400	1400	1400	1400
	Max Capability per Channel (Mbps)	462	100	150	800	800
Power Consumption	Dynamic (mA) (@ 50MHz)	2600	10000	6000	16000	?
(Loaded Tx/Rx's only)	Static (mA)	0.4 (Power on)	40	1840	3402	3818
Noise	Low EMI	+++	---	+	+	++
	Low Bounce	+++	---	+	+	++
Ergonomics	Compact System Size	++	+	+	+	++
	Compact Transmission Medium Size	++	-	+	+	++
	Fans?	No	No	No	Yes	Yes
	Low Weight	+++	-	-	-	+++
Relative System	**Cost Per Board**	**51.05**	**66.12**	**75.04**	**191.04**	**574.22**
	Total	**510.50**	**661.20**	**750.40**	**1910.40**	**5742.20**

Performance Estimate

Cost Estimate						
Subsystem	**Parameter**	**Channel Link**	**TTL**	**GTL/BTL**	**ECL**	**Fibre Channel**
General	Single-Ended or Differential	Differential	Single-Ended	Single-Ended	Single-Ended	Differential
	TTL Bus Width	56	56	56	56	56
	TTL Bus Speed (MHz)	50	50	50	50	50
	Multiplexed Scheme?	Yes	No	No	No	Yes
	Number Tributary Boards	10	10	10	10	10
	Number Channels in Link	10	56	56	56	14
	Number Conductors (Data)	20	56	56	56	28
	Number Conductors (CLK)	1	1	1	1	1
Transceivers	Description	28:5 Channel Link	LVT 16-Bit	GTL 18-Bit	9-Bit	Fibre Channel
	# Transceivers/Board (Trib Board)	4	4	4	14	14
	# Transceivers/Board (Ctrlr Board)	4	4	4	14	14
	Unit Cost	3.70	2.40	3.25	5.00	20.00
	Silicon Cost per Board	29.60	19.20	26.00	140.00	560.00
PC Board	Layers	12	26	26	26	12
	Size (Normalized)	1.15	1	1.15	15.63	11.97
	Total Additional PCB Cost	0.00	100.00	100.00	150.00	50.00
Termination	Voltage	None	None	1.5V	2.1V	3.0V
	Number Termination Regulators	0	0	14	14	14
	Unit Cost	0.00	0.00	1.00	1.00	1.00
	Number Termination Resistors	10	224	128	128	14
	Unit Cost	0.05	0.05	0.05	0.05	0.05
	Number Termination Capacitors	0	0	0	0	0
	Unit Cost	0.00	0.00	0.00	0.00	0.00
	Total Termination Cost	0.50	11.20	20.40	20.40	14.70
Transmission Medium	Type	PCB Trace Backplane	PCB Trace Backplane	PCB Trace Backplane	PCB Trace Backplane	PCB Trace Backplane
	Distance	<1m	<1m	<1m	<1m	<1m
	Layers	12	26	26	26	12
	Size (Normalized)	1	1	1	1	1
	Number Media	1	1	1	1	1
	Additional Media Cost	0.00	200.00	200.00	200.00	0.00
	Total Add'l Trans. Media Cost	0.00	200.00	200.00	200.00	0.00
Connectors	Connector Type	Header	VME	VME	VME	Header
	Number Pins (Data+ CLK)	21	57	57	57	29
	Number Pins (Power/GND)	5	38	38	7	7
	Total Connector Pins	26	96	96	64	36
	Number Connector Pairs	1	1	1	1	1
	Cost of Pair	3.00	10.00	10.00	8.00	3.75
	Connector Cost per Board	3.00	10.00	10.00	8.00	3.75
Power Supply	Special Supply Voltages	0	0	1.5V	2.1V	3.0V
	Power Supply Size (Normalized)	1	1.5	1.5	1.7	1.4
	Total Add'l Power Supply Cost	0.00	50.00	50.00	60.00	40.00
Total Relative System Cost Per Board		**49.21**	**66.64**	**74.84**	**191.04**	**574.22**
Total Relative System Cost		**492.10**	**666.40**	**748.40**	**1910.40**	**5742.20**

Cost Estimate

NOTES